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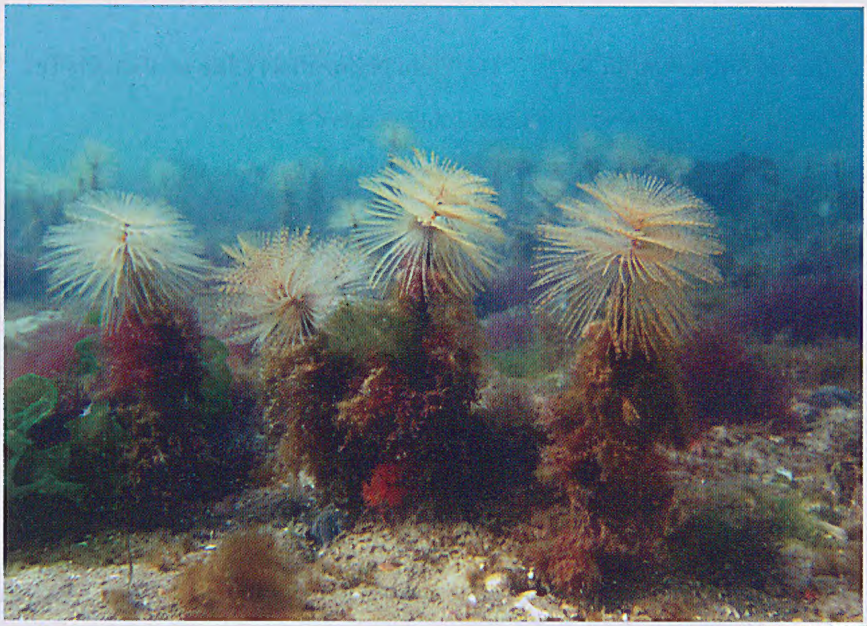

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Front cover: Relatively large *Sabella spallanzanii* (approximately 350–450 mm in total length) exhibiting a very high degree of biofouling by epibionts (both flora and fauna) on the 'tubes'. See page 140.
Back cover: *Perameles obesula* (Geoff), now Southern Brown Bandicoot *Isoodon obesulus obesulus*; drawing by HC Richter for John Gould, from *Australian Marsupials and Montremes*, p.31.

The occurrence of the Southern Brown Bandicoot *Isoodon obesulus obesulus* and its habitat on Chinaman Island, Western Port, Victoria

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Abstract
Anthropogenic influences and pressure from feral predators on the Southern Brown Bandicoot *Isoodon obesulus obesulus* have resulted in the contraction of its distribution, such that it now exhibits a disjunct distribution across its former range. Isolated populations have the potential to become genetic bottlenecks while at the same time being valuable as reservoirs of genetic variability. This paper investigates the occurrence of the Southern Brown Bandicoot on Chinaman Island, Western Port, a locality previously reported as having evidence of the species. In this study, the first direct evidence was obtained of the Southern Brown Bandicoot occurring on the island. Habitat on Chinaman Island was found to be complex. It is described here according to Ecological Vegetation Classes, which are mapped across the island, and physical structure, which was quantified at sampling locations in this area. (*The Victorian Naturalist*, **135 (5)**, 2018, 128–139)

Keywords: Bandicoot, Western Port, Chinaman Island, vegetation

Introduction

The Southern Brown Bandicoot *Isoodon obesulus* is a small to medium-sized marsupial (head-body length 280–355 mm; tail length 80–130 mm; weight 400–1500 g) with five recognised and geographically distinct subspecies. *Isoodon obesulus fusciventer* is found in southern Western Australia; *I. o. nauticus* on the Nuyts Archiplago, South Australia; *I. o. peninsulae* in north Queensland, *I. o. affinis* in Tasmania and *I. o. obesulus* in South Australia, Victoria and New South Wales (Van Dyck and Strahan 2008). This work is restricted in its context to the Southern Brown Bandicoot subspecies *I. o. obesulus,* hereafter SBB.

Omnivorous in diet, the SBB digs for invertebrates (e.g. arthropods, earthworms), plant tubers and fungi, leaving distinctive conical holes (Menkhorst and Knight 2004). Fruit, seeds and other plant material found above ground are also important dietary components (Threatened Species Scientific Committee [TSSC] 2016). The SBB occurs in a wide range of vegetation types (Maclagan 2016) and is known to be sensitive to the availability of dense, low cover that provides protection from predators (Bennett 1993; Rees and Paull 2000; Paull 2008).

Habitat fragmentation and modification due to human disturbance, changes in fire regimes, and predation by the introduced Red Fox *Vulpes vulpes* and Feral Cat *Felis catus* (Brown and Main 2010) have seen the continued decline of SBB across its Victorian range. Historically distributed in a broad coastal band from South Australia to New South Wales, the SBB now has a disjunct distribution across this former range. The species is now listed as 'Threatened' under the Victorian *Flora and Fauna Guarantee Act 1988* and as 'Endangered' under the Australian *Environment Protection and Biodiversity Conservation Act 1999.*

Conservation measures to assist the recovery and persistence of the SBB and its habitat have been developed and implemented (Brown and Main 2010). Nonetheless, SBB populations persisting on the south-eastern fringes of Melbourne face ongoing pressure from habitat loss due to urbanisation (Lechner 2006). Recently, the Victorian Government promised to ensure the persistence of the SBB within a defined management area south-east of Melbourne (Department of Environment and Primary Industry [DEPI] 2014; Department of Environment, Land, Water and Planning [DELWP] 2015), which covers a complex mosaic of agricultural and outer-urban areas, as well as patches of remnant bushland. Within this landscape, there are several sizeable areas of confirmed or potential SBB habitat, including the Royal Botanic Gardens at Cranbourne (Coates *et al.* 2008). These areas are crucial for the persistence of the SBB in Victoria and will be important targets for habitat management. If occupied by SBB, they may act as source populations for potential genetic rescue measures, and if unoccupied they may act as SBB release sites (DEPI 2014). A thorough knowledge of

the genetic makeup of SBB at many sites is critical for such actions.

Chinaman Island, in Western Port, is a potentially important refuge for SBB on Melbourne's fringe, being a large (~104 ha) and relatively undisturbed area of natural vegetation. However, little is known about the SBB population status and available habitat on Chinaman Island. This study aimed both to determine whether the island was occupied by SBB and to describe the vegetation types and vegetation structure of the island.

Evidence would suggest that SBB occurs on Chinaman Island—since it occurs on Quail Island (Maclagan 2016), immediately west of Chinaman Island (210 m apart at their closest point at high water) (Fig 1.), and historically on the mainland adjacent to Chinaman Island (Victorian Biodiversity Atlas, DELWP). Legg (2013) alluded to the diversity of vegetation on the island, which exhibits a gradient from salt- to freshwater and from waterlogged soils to well-drained sands. Conical diggings typical of SBB previously have been recorded on Chinaman Island (Braithwaite *et al.* 1980; Legg 2010; Legg 2013) but there have been no direct, definitive records of the species on the island.

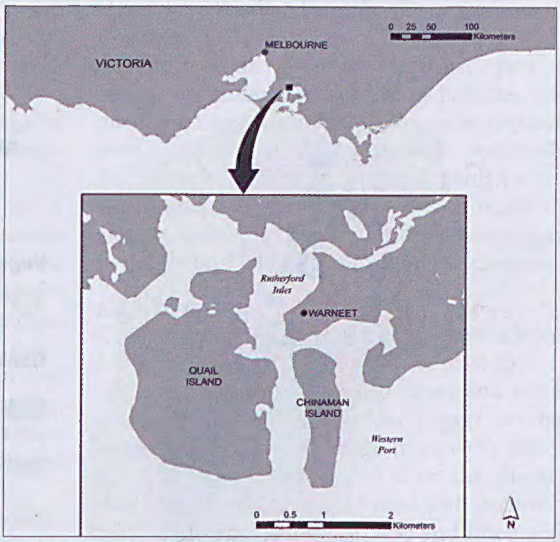

Fig 1. The location of Chinaman Island within Western Port, Victoria.

The aims of this study were to:

1. map the distribution of Chinaman Island's Ecological Vegetation Classes (EVCs);
2. determine the availability of habitat structure appropriate for SBB across the island; and
3. confirm the presence of SBB on Chinaman Island using both camera surveys and live trapping.

Methods

Study Area

Chinaman Island is part of the 'North-Western Port Nature Conservation Reserve', located within Western Port, Victoria (Fig. 1). The island is a little over 2 km long (north–south) and up to 600 m wide (east–west) and separated from the mainland by a narrow mangrove-lined channel that drains at low tides to expose mud. The island is composed of undulating beds of grey to yellow sand (forming part of the 'Cranbourne Sands' described by Holmes *et al.* 1940) overlying ferruginous sandstones (Rosengren 1984). Such sands are low in nutrients and drain readily. However, in some places layers of 'coffee rock' (dark brown, cemented sand layers) impede drainage. It is very similar geomorphologically and ecologically to the larger Quail Island, which lies to its west.

Vegetation assessment

To enable comparisons of the vegetation of Chinaman Island with that of other areas of confirmed or potential SBB habitat, we mapped the distribution of different vegetation types and quantitatively described the structure of each of the widespread types.

Vegetation patterns were described by assigning each area to an EVC, using the current DELWP typology (Oates and Taranto 2001; Bull and Sinclair 2014). To do this, aerial photographs (Google Earth) were used to delineate phototypes i.e. areas of distinctive visual appearance, visible on aerial images, which are likely to represent discrete vegetation types. These were then checked in the field, on 16 and 18 August 2016. Polygon boundaries were adjusted, where necessary, after the field work. Given the importance of habitat structure to SBBs, and the emphasis on species composition in the EVC typology, several EVCs were

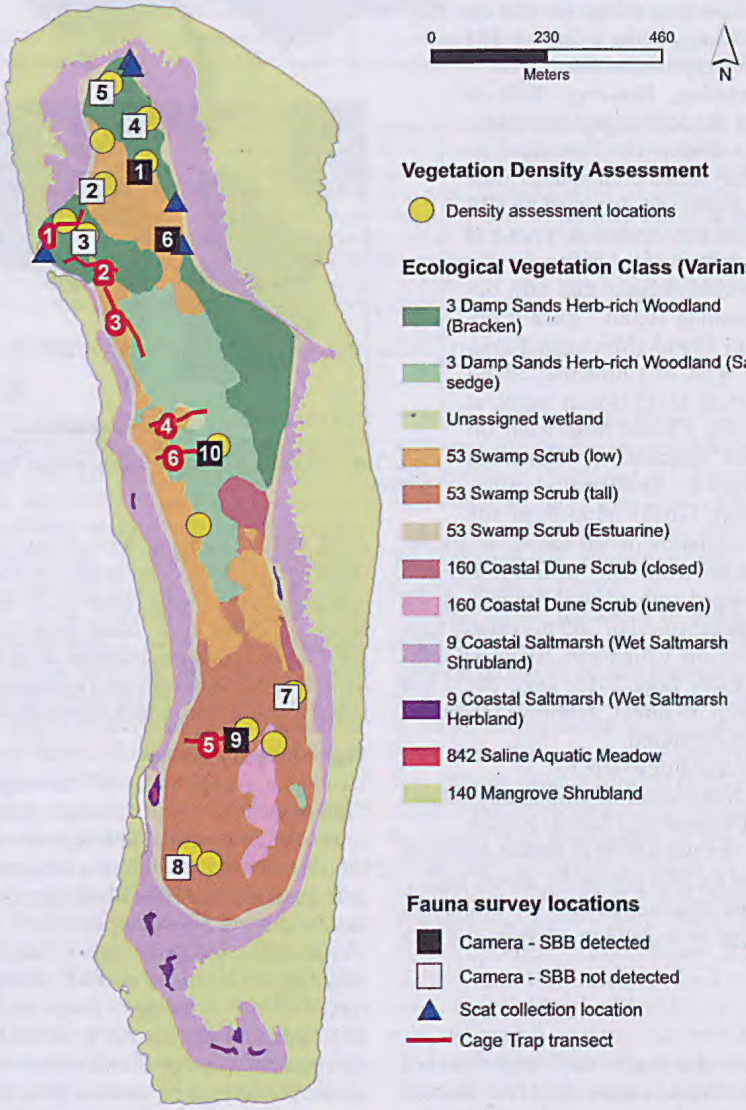

Fig 2. Ecological Vegetation Class mapping with location of vegetation density assessments and fauna survey sites by method. (SBB = Southern Brown Bandicoot)

split into informal 'structural variants' based on conspicuous but subjectively-defined differences in their structure (e.g. Bracken versus Saw-sedge dominated understorey).

Vegetation density was assessed at 14 sites across the island (Fig. 2). These were stratified by the phototypes initially defined, and fall across the main terrestrial vegetation EVCs (Damp Sands Herb-rich Woodland, Swamp Scrub and Coastal Dune Scrub). The transects were positioned by phototype before the variants were defined (Fig. 2) and consequently all variants of each EVC were combined. We also combined Swamp Scrub and Coastal Dune Scrub into one category. This resulted in two main terrestrial vegetation types, 'Scrub' and 'Woodland', being assessed for density.

At each location a 25 m transect was established along a random bearing. Data were collected from 25 points, 1 m apart, along each transect. At each point the vegetation density was assessed at four height strata (0–20 cm, 20–50 cm, 50–100 cm and 100–200 cm) by counting the number of times vegetation touched a vertical pole in each stratum. The density of the vegetation in each stratum was calculated simply by dividing the number of touches recorded in the stratum by the vertical extent of the stratum (see Fig. 5).

Collection and analysis of predator scats

Predator scats (Red Fox and Feral Cat) were collected opportunistically during the vegetation assessment. Features of guard hairs (diameter, colour, shaft, cuticle pattern, medulla, scale patterns and root) found within the scats were examined using a light microscope to determine the probable source and composition of prey.

Camera trapping

Ten remote cameras (Reconyx HC600) were deployed on Chinaman Island on 1 September 2016 and remained *in situ* for 21 nights (programmed to record both day and night). Three cameras were located randomly within each of the three most widespread vegetation types (Fig. 2). A tenth camera (Camera location 10) was positioned to target possible SBB diggings and scats noted in a variant of the Damp Sands Herb-rich Woodland during the vegetation assessment.

Cameras were mounted on either trees or stakes, depending on site characteristics, and positioned approximately 40 cm above ground-level, targeting small to medium mammals. Herbivore bait (composed of oats, golden syrup and peanut butter) was infused with truffle oil and housed within a bait holder that was pegged to the ground 2–2.5 m in front of the camera.

Cage trapping

Cage trapping was conducted to obtain samples for genetic analysis. All traps were 59 × 30 × 17 cm in size with gravity drop doors and either a treadle plate or bait holder trigger mechanism. Between 5 and 7 cage traps were placed along six transects accessed from the western side of the island (Fig. 2), baited with herbivore bait (as per the camera survey) and fitted with plastic covers to keep the traps dry within. The traps along five of these transects were left *in situ* for four nights (8–11 May inclusive), and traps on the sixth transect (No. 6), established on 9 May, left *in situ* for three nights (9–11 May inclusive), totalling 125 trap nights. Traps were cleared and reset in the morning and afternoon of each day.

Results

Vegetation assessment

Vegetation patterns per Ecological Vegetation Class

Chinaman Island supports 44 ha of terrestrial vegetation above the high tide mark, and a fringe of intertidal vegetation covering approximately 60 ha surrounding the island. All vegetation on Chinaman Island was determined to be native vegetation (using the criteria of DEPI 2014). The area of the intertidal vegetation is approximate because the mangrove fringe is contiguous with the mangrove fringe on the mainland coast, and was therefore divided from the mainland arbitrarily (Fig. 2).

We assigned Chinaman Island's vegetation to six EVCs, described below (Figs 3 and 4).

Damp Sands Herb-rich Woodland (EVC 3)

This EVC (16.3 ha, 37.3% of terrestrial vegetation) grows extensively on Chinaman Island, as it does on the adjacent Quail Island and the mainland coast. Locally, it occurs on thin but

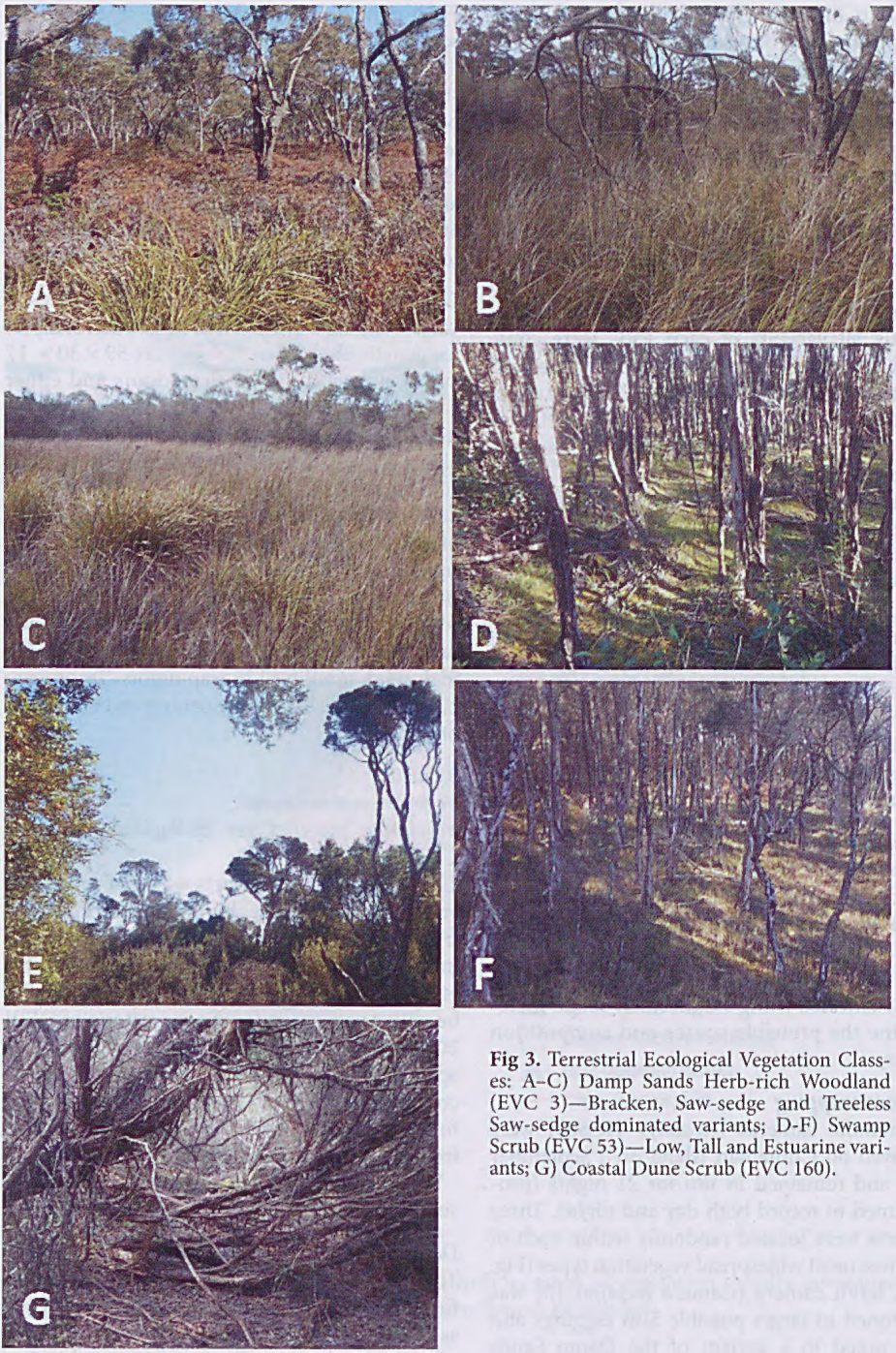

Fig 3. Terrestrial Ecological Vegetation Classes: A–C) Damp Sands Herb-rich Woodland (EVC 3)—Bracken, Saw-sedge and Treeless Saw-sedge dominated variants; D-F) Swamp Scrub (EVC 53)—Low, Tall and Estuarine variants; G) Coastal Dune Scrub (EVC 160).

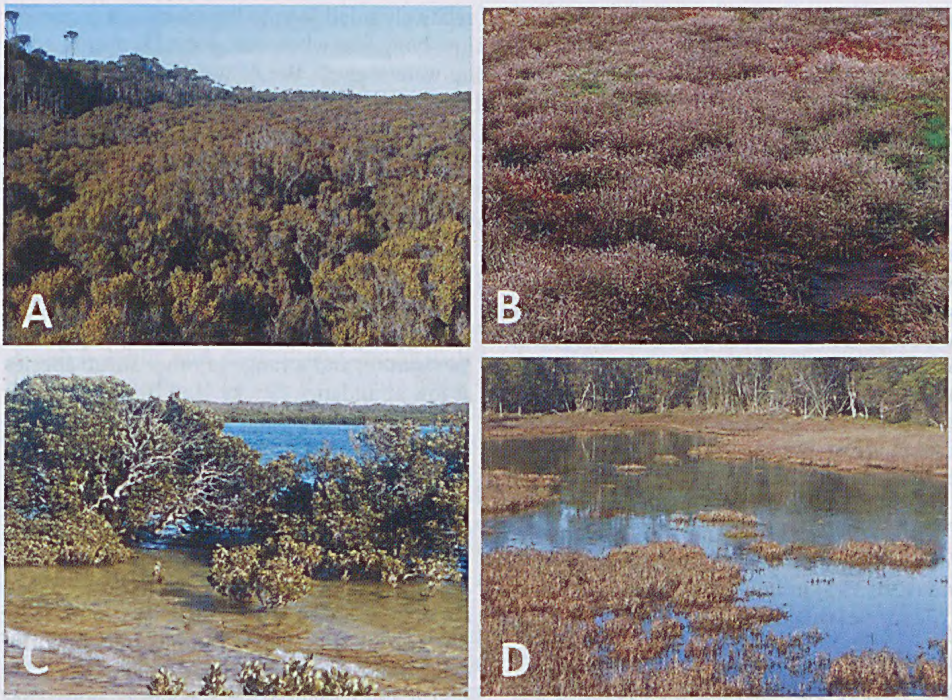

Fig 4. Intertidal Ecological Vegetation Classes: A–B) Coastal Saltmarsh (EVC 9)—Wet Saltmarsh Shrubland and Wet Saltmarsh Herbland variants; C) Mangrove Shrubland (EVC 140); D) Saline Aquatic Meadow (EVC 842).

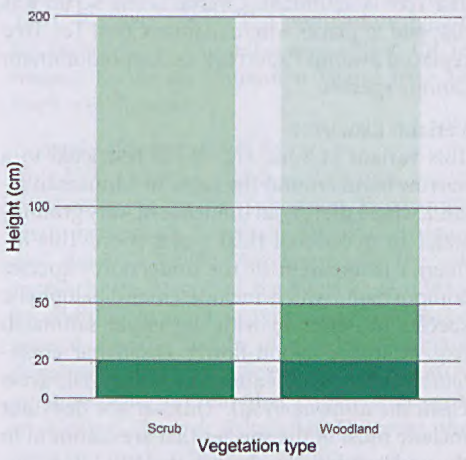

Fig 5. The relative mean vegetation density at different strata by vegetation type. Darker colours indicate higher relative vegetation density (as measured by structure pole touches/m) and lighter colours indicate lower relative vegetation density.

mainland coast. Locally, it occurs on thin but relatively well-drained sand sheets overlying more fertile sandstone substrates (Oates and Taranto, 2001). This vegetation on Chinaman Island supports a canopy composed entirely of Manna Gum *Eucalyptus viminalis*. The middle storey supports patchy stands of shrubs, the most common being Tea-trees *Leptospermum continentale* and probably *Leptospermum scoparium*, and—in wetter areas approaching Swamp Scrub (below)—Swamp paperbark *Melaleuca ericifolia*. In the map data, we distinguished two informal structural variants, based on differences in the composition of the ground layer, as described below.

Variant: bracken understorey

This variant (8.7 ha, Fig. 3A) occurs on more elevated parts of the island, where the sandy soil is deeper. The ground layer is strongly dominated by a dense and tall layer of Austral Bracken *Pteridium esculentum*. Other species in the ground layer include many that are

typical of this EVC, such as Spiny-headed Mat-rush *Lomandra longifolia*, Weeping Grass *Microlaena stipoides*, Common Raspwort *Gonocarpus tetragynus*, Blue Bottle-daisy *Lagenophora stipitata*, Small Gnat-orchid *Cyrtostylis reniformis* and Nodding Greenhood *Pterostylis nutans*.

Variant: Saw-sedge understorey

This variant (7.6 ha, Fig. 3B-C) occurs on lower lying sand sheets than the bracken-dominated variant, where the sandy soil is presumably shallow, and the damp subsoil is closer to the surface. The ground layer is strongly dominated by a dense layer of Thatch Saw-sedge *Gahnia radula*, which forms a monoculture in some areas. The species listed above for the bracken-dominated variant are present, but at very low abundance. While this vegetation is here placed within Damp Sands Herb-rich Woodland, it approaches Damp Heathy Woodland (EVC 793) in its context, but it lacks most of the species that distinguish that EVC.

Swamp Scrub (EVC 53)

This EVC (25.2 ha, 57.3% of terrestrial vegetation) occurs on fertile, waterlogged clays or clay-loams, dominated by a dense canopy of shrubs in the family Myrtaceae (Oates and Taranto, 2001; Bull and Sinclair 2014). On Chinaman Island, the vegetation is strongly dominated by Swamp Paperbark *Melaleuca ericifolia*. The understorey includes scattered small shrubs (e.g. Hop Goodenia *Goodenia ovata*, Prickly Moses *Acacia verticillata* and Austral Indigo *Indigofera australis*). The ground layer is rich in small herbs, including Kidney Weed *Dichondra repens*, and a notably rich and abundant orchid flora (predominantly including Small Gnat-orchid *Cyrtostylis reniformis*, Nodding Greenhood, Trim Greenhood *Pterostylis concinna*, Tall Greenhood *Pterostylis melagramma*, Maroon Hood *Pterostylis pedunculata* and Slaty Helmet-orchid *Corybas incurvus*). Three variants of this EVC were recognised, based on the different structure of the canopy and composition of the ground layer.

Variant: low

This variant (8.6 ha, Fig. 3D) is characterised by a homogeneous, dense and even canopy of relatively small Swamp Paperbarks. It occurs on low-lying flats where the ground is presumed to be waterlogged. The relatively small stature of the Paperbarks may be due to curtailed growth under waterlogged conditions, or the age of the vegetation, but the former explanation is considered more likely.

Variant: tall

This variant (12.1 ha, Fig. 3E) is characterised by a tall, uneven canopy dominated by large spreading Swamp Paperbarks, along with occasional plants of Coast Tea-tree *Leptospermum laevigatum*, and a range of other shrub species at low abundance (Sticky Hop Bush *Dodonaea viscosa* subsp. *spatulata* and several *Acacia* species). The ground layer is as described above for the EVC.

This variant seems to occur on land that is slightly more elevated and sandy than the 'low' variant, although this distinction is not always obvious. The large size of the Swamp Paperbarks may be related to their age, or to their position in suitable conditions, but the latter explanation is considered most likely.

Also, this variant of Swamp Scrub approaches Coastal Dune Scrub (described below) in places where the sand is relatively deep and Coast Tea Tree is abundant. Coastal Dune Scrub was mapped in places where mature Coast Tea Tree replaced Swamp Paperbark as the predominant canopy species.

Variant: Estuarine

This variant (4.5 ha, Fig. 3F) is restricted to a narrow band around the coast of Chinaman Island, where there is an influence of salty groundwater or occasional tidal penetration. This influence is apparent in the understorey species composition, which includes many halophytic species in common with the upper saltmarsh (e.g. Rounded Noon-flower *Disphyma crassifolium* subsp. *clavellatum*, Australian Salt-grass *Distichlis distichophylla*). This variant does not include most of the species that are common in the understorey elsewhere in this EVC. The canopy is a homogeneous, dense and even stand of relatively small Swamp Paperbarks. This vegetation corresponds exactly to 'Estuarine Swamp Scrub' of Oates and Taranto (2001).

Coastal Dune Scrub (EVC 160)
This EVC (2.4 ha, 5.5% of terrestrial vegetation) describes vegetation of dense shrubs and small trees on well-drained, near coastal sand dunes and sand-sheets. On Chinaman Island, it is characterised by dense stands of Coast Tea-tree, with a ground layer of thick litter, and a sparse coverage of forbs, ferns and grasses. Occasional plants of Hedge Wattle *Acacia paradoxa*, Prickly Moses and Sticky Hop Bush occur throughout (Fig. 3G).

The distinction between this EVC and Swamp Scrub is subtle and gradual on Chinaman Island, presumably reflecting the slight changes in sand depth over the waterlogged subsoil, along with the temporal changes in the relative cover of Swamp Paperbark and Coast Tea-tree that is associated with growth, senescence and recruitment of these species. This EVC was mapped only where Coast Tea-tree was overwhelmingly dominant. All transitional zones were assigned to Swamp Scrub.

Coast Tea-tree is indigenous on the Western Port coast, but may invade adjacent vegetation following clearing, burning, nutrient elevation or grazing, and it is sometimes considered to indicate habitat degradation and to warrant control (Hazard and Parsons 1977; Burrell 1981; Bennett 1994). The population dynamics and status of Coast Tea-tree within the tall Swamp Scrub on Chinaman Island have not been established.

Coastal Saltmarsh (EVC 9)
This EVC (18.3 ha, 30.5% of intertidal vegetation) occurs in the intertidal zone. Two variants were recognised, based on different structure and floristics, which correspond to the saltmarsh types described by Boon *et al.* (2015). In addition to the two types described below, several narrow bands of Coastal Saltmarsh dominated by Coast Spear-grass *Austrostipa stipoides* were present that could be assigned to 'Coastal Tussock Saltmarsh'. However, they were too small to warrant mapping.

Variant: Wet Saltmarsh Shrubland
This variant (Fig. 4A) covers 17.9 ha of Chinaman Island. It occurs in tidally-inundated areas that are relatively free-draining and is characterised by the strong dominance of Shrubby Glasswort *Tecticornia arbuscula*. Other species are rarely encountered, but include patches of Marsh Saltbush *Atriplex paludosa* subsp. *paludosa* at the landward side. This vegetation corresponds exactly to 'Wet Saltmarsh Shrubland' of Boon *et al.* (2015).

Variant: Wet Saltmarsh Herbland
This variant (Fig. 4B) covers 0.4 ha of Chinaman Island. It occurs in areas that are relatively poorly-drained and is characterised by the strong dominance of the succulent herb Beaded Glasswort *Sarcocornia quinqueflora* subsp. *quinqueflora*. Other species are rarely encountered, but include Trailing Jointweed *Hemichroa pentandra*. This vegetation corresponds exactly to 'Wet Saltmarsh Herbland' of Boon *et al.* (2015).

Mangrove Shrubland (EVC 140)
This EVC (~42 ha, 70% of intertidal vegetation) occurs in the intertidal zone, in areas that are deeply inundated most days of the year, and is dominated by Grey Mangrove *Avicennia marina*. Apart from Beaded Glasswort and Shrubby Glasswort on the upper margin where the mangroves meet saltmarsh, no other species of vascular plant occurs in this EVC on Chinaman Island. Mangrove Shrubland is shown in Fig. 4C. Approximately 42.0 ha of this EVC surround Chinaman Island.

Saline Aquatic Meadow (EVC 842)
This EVC (<0.1 ha, 0.2% of intertidal vegetation) occurs in pools within the intertidal zone which may contain salt water for extended periods (months), but also remain dry during other periods. The vegetation is dominated by Water Mats *Lepilaena* sp. and a range of algae. Saline Aquatic Meadow is shown in Fig. 4D. It covers less than 0.1 ha of Chinaman Island.

Unassigned wetland vegetation.
A very small area (0.1 ha) of treeless sedgeland was unable to be adequately assigned to an EVC. It occurred in a low depression, where the boggy, heavier subsoil was exposed. Although it was low-lying and close to the coast, no species characteristic of saline or brackish habitats were noted, suggesting that fresh water seeps from the sand sheets or fresh groundwater meets the surface in this area. It may provide an important source of fresh water for animals

living on the island. The vegetation is treeless and strongly dominated by Thatch Saw-sedge, along with Spiny-headed Mat-rush, Variable Sword Sedge *Lepidosperma laterale* and Weeping Grass. This vegetation does not fit comfortably within the EVC typology. It is similar to Damp Heathland (EVC 710) or Wet Verge Sedgeland (EVC 932) in its context, but lacks many of the distinctive species of those EVCs.

Density and structure

Vegetation density was highest in the lowest strata (0–20 cm) for both vegetation types. The mean vegetation density for Scrub was uniform above 20 cm. We observed a different pattern in woodland, where vegetation density declined as height increased, up to 200 cm (Fig. 5).

Southern Brown Bandicoot survey

Analysis of predator scats

Nine of the thirteen scats analysed were attributed to Red Fox, two to either Red Fox or Cat and two were indeterminate. Black Rat *Rattus rattus* hair, bird feathers and evidence of crustacea and insects were recorded from Red Fox scats, with Swamp Rat *Rattus lutreolus* hair and bird feathers and bones recorded from unidentified predator scats. No SBB remains were detected in any scat.

Camera survey

SBB were recorded on four of the 10 cameras (Table 1, Fig. 2). A further record (at location 3) could not be positively identified as SBB. However, this is the most likely species. These detections were spread across the four vegetation types targeted and broadly distributed across the island. An additional three marsupial, two rodent and one canid species were recorded (Table 1, Fig. 6). Of these, the Black Rat *Rattus rattus* and Red Fox *Vulpes vulpes* are introduced.

Cage trapping

Cage trapping yielded one SBB (8 May, Fig. 7C) and two Swamp Rats *Rattus* (9 May, trap 4-3 and 10 May, Fig. 7A), all from transect 4 (Fig. 2).

Discussion

This work is the first to confirm the presence of SBBs on Chinaman Island with direct evidence. Observed conical diggings (Fig. 7D) on the island, recorded on multiple occasions over an extended time (>30 years), strongly suggested their presence. Additionally, the considerable overlap in EVCs on the island with those on neighbouring Quail Island and the broader adjacent mainland where SBB have previously been recorded, suggested suitable habitat.

The relatively modest level of survey coverage and the types of faunal survey techniques employed (scat analysis, camera traps, cage traps) as part of this work limit any informed statements on SBB abundance, demography, or population status. However, we can infer that while the SBB appears to be widespread across both terrestrial vegetation types and the island itself, they may be in low numbers. This is supported by the lack of detection on previous camera trap surveys (Legg 2010; Legg 2013), and by this work in the low number of SBB detected by cameras, the solitary capture of a SBB by cage trapping, and the lack of evidence of SBB in predator scats.

Whether the Chinaman Island SBB population is at carrying capacity or is suppressed by other factors is unknown. We recorded a catch rate of 0.08 SBB/trap-night cage trappings over 125 trap nights (26 traps × 1 night, 33 traps × 3 nights). Comparative catch rates for Quail Island are 0.042 over 240 trap-nights (60 traps × 4 nights) in April 2013, 0.011 over 180 trap-nights (60 traps x 3 nights, inclement

Table 1. Mammals recorded on remote cameras on Chinaman Island. *Probable Southern Brown Bandicoot, photos didn't allow for certain identification. Number within parentheses ( ) is the number of days SBB detected over the camera trap deployment.

Common name	Scientific name	Sites/Camera
Southern Brown Bandicoot	*Isoodon obesulus*	1(3), 3*(1), 6(4), 9(1), 10(1)
Swamp Rat	*Rattus lutreolus*	8
Black Rat	*Rattus rattus*	5, 7
Short-beaked Echidna	*Tachyglossus aculeatus*	2, 3, 4, 6, 9, 10
Common Brushtail Possum	*Trichosurus vulpecula*	2, 3, 4, 6
Red Fox	*Vulpes vulpes*	1, 3, 4, 9
Black Wallaby	*Wallabia bicolor*	3, 4, 5, 6, 7, 8, 9, 10

Fig 6. Species recorded on Chinaman Island using camera traps from 1–22 September 2016. A) and B) Southern Brown Bandicoot; C) Swamp Rat, D) Short-beaked Echidna; E) Common Brushtail Possum; F) Black Wallaby; G) Red Fox; and H) Black Rat.

Fig 7. Species captured on Chinaman Island using cage traps between 8 May 2017 and 12 May 2017. A) and B) Swamp Rat and Swamp Rat dig respectively; C) and D) Southern Brown Bandicoot and conical Southern Brown Bandicoot dig respectively.

weather) in September 2013, and 0.0125 over 240 trap-nights (60 traps × 4 nights) in April 2014 (Sarah Maclagan, pers. comm.). Trapping across 14 mainland forest patches in the Mount Burr Range of south-eastern South Australia resulted in a mean capture rate of 0.019 (5627 trap nights) (Li *et al* 2015).

Predation by feral species is likely to be the greatest threat to the Chinaman Island SBB population. Red Foxes were detected at four of the ten camera trap sites, which include some where SBB was detected. Scat analysis also suggested feral cats occur on Chinaman Island. Additional monitoring would be required to determine this.

Analysis of hair from predator scats previously has shown the Southern Brown Bandicoot to be a regular prey item of foxes and feral cats (Brown and Triggs 1990; Doherty *et al.* 2015). The fact that we did not detect SBB hair in scats may reflect the very small scat sample size collected, both temporally and spatially, rather than any true indication of predation pressure. It is possible also that there is low predation pressure from foxes. Sites with greater vegetation density are preferred by bandicoots (Brown and Main 2010) and the thick understorey across much of the island as shown by the vegetation density analysis would be expected to offer a reasonable level of protection from predators.

The single SBB capture as part of this work is insufficient to gain an understanding of the animal's genetic profile on Chinaman Island or to inform any broader Genetic Rescue program. Nor is it possible to determine whether the Chinaman Island population is isolated from other nearby populations. It is not known whether SBB traverse saltmarsh and mangrove vegetation, but it is conceivable that animals move between the mainland and the island.

Our analysis of the vegetation of the island, which forms the habitat of the SBB, revealed it to be rich and varied. Given that the occurrence of the SBB was confirmed across much of the island, our vegetation structural descriptions can be used as quantitatively defined exemplars of confirmed bandicoot habitat structure. We hope these will prove useful in informing future studies.

Acknowledgements

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Symposium paper

Quantification of the abundance and efficacy of removal of the giant fan worm *Sabella spallanzanii*, at Point Cooke Marine Sanctuary

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Abstract
The giant or European fan worm *Sabella spallanzanii* is recognised as one of the most invasive marine pest species to have infiltrated southern Australian waters. It has spread throughout much of Port Phillip Bay since it was discovered there in the late 1980s, and poses a threat to the marine ecology and biodiversity of many coastal Victorian areas. Pilot surveys carried out during a number of recreational snorkeling and scuba diving excursions revealed that some areas of Point Cooke Marine Sanctuary in Melbourne's west supported considerable patches or 'hotspots' of this fan worm, with significant densities observed. Further investigation has revealed that densities throughout much of the marine sanctuary remain relatively minimal, in accordance with previous findings. The relatively large size of *S. spallanzanii* and the ease with which it can be removed from the benthos means that it is a good candidate for removal by marine friends groups and 'citizen science' initiatives, if these are warranted in marine protected areas, but at present it appears that *S. spallanzanii* is far from being able to exert a significant impact on Point Cooke Marine Sanctuary and the surrounding environment. (*The Victorian Naturalist* 135 (5), 2018, 140–153)

Keywords: invasive marine pest species, Point Cooke Marine Sanctuary, *Sabella spallanzanii*, abundance, density

Introduction

Sabella spallanzanii (Gmelin 1791), a polychaete annelid known alternatively as the giant European or Mediterranean fan worm, is an invasive marine pest species that was first detected in the Geelong arm of Port Phillip Bay in the late 1980s (Carey and Watson 1992). In subsequent years, it spread to numerous locations throughout Port Phillip Bay, (Parry *et al.* 1996; Cohen *et al.* 2000; Currie *et al.* 2000) and other locations throughout the world from its native zone of the Mediterranean Sea and the eastern Atlantic Ocean off north-western Africa (Ross, Longmore and Keough 2013). *Sabella spallanzanii* was presumably introduced as a consequence of hull fouling and/or ballast water discharges from shipping activities (Aquenal 2008). It has been identified as one of the most invasive marine pest species to have infiltrated southern Australian waters thus far, owing to its ability to rapidly colonise various marine locations, especially disturbed habitats, and various anthropogenic structures. Its considerable filter-feeding capacity allows it to compete with (and potentially outcompete) a variety of native organisms (Aquenal 2008; Ross *et al.* 2013) (Fig. 1). The level of concern regarding this particular marine pest has been such that a National Control Plan was developed in an effort to limit its spread and pervasiveness within southern Australian marine habitats (Aquenal 2008).

In Victoria, Marine Protected Areas (MPAs) have drawn considerable attention recently. This follows an investigation into MPAs in 2013, which was carried out by the Victorian Environmental Assessment Council (VEAC) in partial response to an Auditor General's report on their management (Pearson

Fig. 1. Two examples of *Sabella spallanzanii* amongst native soft corals at Point Cooke Marine Sanctuary.

2011). One issue highlighted by both reports was introduced marine pest species, which at last count numbered over 120 introduced and cryptogenic (status uncertain, i.e. they could be native or introduced) floral and faunal species in Port Phillip Bay alone (Hewitt *et al.* 2004).

Point Cooke Marine Sanctuary (PCMS) is a 290 ha marine protected area in Melbourne's west, approximately 25 km from the Melbourne CBD. This MPA features a wide range of habitats, including basalt reefs and boulders, seagrass meadows, sand and mud patches, and some anthropogenic artefacts (including a derelict jetty and at least two shipwrecks), all of which have been identified as examples of suitable habitats for *S. spallanzanii*. Moreover, PCMS fits within the accepted description of the preferred habitat of *S. spallanzanii*, as it is relatively sheltered and nutrient rich (Aquenal 2008). PCMS features a wide range of marine flora and fauna, with plentiful macroalgae, crustaceans, molluscs including gastropods and cephalopods, echinoderms, and fish (both teleosts and chondrichthyans).

Observations of PCMS since 2014 (mainly during recreational snorkeling and scuba diving excursions) revealed that there were some sizable populations and patchy abundances of *S. spallanzanii* throughout the sanctuary, with some areas showing what appeared to be a significant degree of colonisation (Fig. 2).

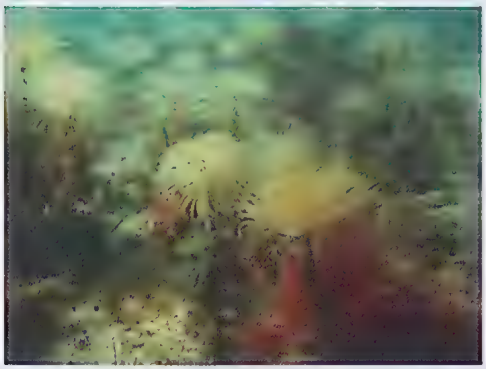

Fig. 2. A dense colony of *Sabella spallanzanii*, photographed in approximately four metres of water at Point Cooke Marine Sanctuary in August 2014 during a recreational snorkel, which served as the inspiration for this study and led to a successful grant application being submitted to the Environment Fund of the Field Naturalists Club of Victoria.

While a number of surveys have been conducted at PCMS since 2003, there was a paucity of information concerning the densities, size-frequency distribution and efficacy of physical removal of *S. spallanzanii* from this particular marine protected area. Edmunds *et al.* (2009) mentioned that *S. spallanzanii* was detected sporadically at PCMS, and occurred in relatively low abundances, but that the data gathered during surveys was somewhat inconsistent and not fit for publication. This study therefore aimed to investigate, quantify and record data at PCMS on each of these key aspects relating to *S. spallanzanii* and to compare it to data from Gem Pier in Williamstown, a local area with a known heavy infestation of the fan worms, to give these findings some context. It was hoped that the conclusions of this study would prove useful for future management of this marine pest at PCMS, and possibly other localities within Port Phillip Bay and elsewhere.

Materials and methods

Since anecdotal observations of *S. spallanzanii* at PCMS revealed 'hotspots' of abundance on the benthos in the subtidal region at depths of four to six metres at high tide, most of the sampling for this project was conducted within this region, which translates to distances of 300 to 600 metres offshore. Sampling in the shallow subtidal region aimed to provide an overview of the densities of these pests for the vast majority of the marine sanctuary, which ranges in depth from zero to four metres at high tide. Some of this sampling was carried out during recreational snorkelling activities, during which *S. spallanzanii* were photographed or filmed opportunistically when encountered.

Transect line sampling

A variety of habitats were sampled as part of this project, and recordings made on underwater slates (Scubapro, El Cajon, California) and waterproof paper (Meter Colour Laser Products, Sydney). Transects of 10 m lengths were surveyed; the transect lines themselves consisted of two 1 kg weight plates that were tied to either end of a 10 m long section of polypropylene rope, which was marked at 1 m intervals with PVC tape. The transect lines were wound around a spool prior to deployment, and then

unwound when ready for deployment. *Sabella spallanzanii* that were encountered up to 1 m to the side of the transect line (measured with either a ruler or with the assistance of a 1 m^2 quadrat) were recorded and/or physically removed, and their location along the transect line recorded.

In total, 120 m^2 of PCMS were surveyed, consisting of 12 separate transect lines each with an area of 10 m^2. Still photographs and video footage were taken as further qualification and quantification tools throughout various aspects of this experiment, including transect line sampling (Fig. 3).

Fig. 3. Joel Pasnin conducting photographic surveys of *Sabella spallanzanii* within Point Cooke Marine Sanctuary. Photo: Joel Pasnin, Melbourne Polytechnic.

Quadrat sampling

The quadrats used in this investigation were 1 m^2 in area, and were constructed of PVC pressure pipe, with a ball valve fitted to allow flooding and sinking when required (Fig. 4). These were deployed upon various substrate types to determine densities of *S. spallanzanii*. At selected locations, a 5 kg weight plate (Kmart, Melbourne) with an approximately 1 m long section of rope tied to a polystyrene buoy (and then cable tied as an additional method of securing the very buoyant float), were laid out at various points of the sanctuary so that these locations could be surveyed at later dates to determine the efficacy of physical removals and rates of re-invasion. These locations were chosen in a haphazard manner, and were reflective of low-, medium- or high-level infestations of these marine pests. Unfortunately, this part of the investigation was discontinued when the floats and associated ropes disappeared; the fact that the weight plates were recovered was strongly suggestive of deliberate sabotage, possibly as a result of boaters stealing the floats, which can be used for a variety of purposes. Instead, the ease (or otherwise) of physical removal from the substrate was documented.

Morphometric analysis

A number of *S. spallanzanii* were removed from PCMS using gloved hands, after which they were

Fig. 4. (Left): A 1m^2 PVC-based quadrat that was developed for this investigation in a disassembled state. The rubber collar fasteners allow the quadrat to be disassembled for ease of transportation; the quadrat can then be reassembled when ready to perform marine survey work. (Right): An example of a 5 kg weight plate with the marker buoy attached, demonstrating extensive fouling. This component of the investigation was abandoned due to sabotage (when the buoys and sections of rope disappeared).

placed into a spring-loaded catch bag (Oceanpro, San Leandro, California), then loaded into an 80 L capacity plastic tub, and transported back to the Epping campus of Melbourne Polytechnic for subsequent morphometric analysis. This was to determine size-frequency distributions and provide associated information. A total length measurement, accurate to the nearest millimetre, was taken initially with a ruler or tape measure, followed by a total mass reading using an electronic balance accurate to 0.1 g (Livingstone International, Sydney). A small number of animals (47) then had their external casings removed to determine a more accurate length vs mass relationship, since some tubes were shown to be prone to biofouling. In total, 161 *S. spallanzanii* featured as part of the length vs mass regression analysis. Because of their status as an introduced marine pest species, no *S. spallanzanii* were at any stage returned to the water, and all were euthanised and disposed of in biohazardous waste bags following analysis.

Permits for sampling and removals from a marine protected area

Sabella spallanzanii examined as part of this investigation, either *in situ* or in the laboratories of Melbourne Polytechnic's Epping campus, were treated in accordance with the requirements and provisions of permit NP192 (Noxious Aquatic Species) issued by the Department of Environment and Primary Industries, and permit 10007582 (Research Permit), issued by the Department of Environment, Land, Water and Planning.

Results and Discussion

Densities of* S. spallanzanii *at Point Cooke Marine Sanctuary

As expected, the presence of *S. spallanzanii* in the shallow intertidal areas of PCMS was found to be so uncommon as to be virtually negligible (with only one individual sighted), and the same was true for much of the shallower subtidal region, with only very sparse densities noted. In the deeper subtidal region, however, there appeared to be some zones or 'hotspots' (most notably close to the boundaries of the marine sanctuary) that supported considerable densities of *S. spallanzanii*. In particular, there were some relatively high densities in areas just inside the sanctuary boundary offshore from emergency location PCC504 (coordinates 37°55.656' S and 144° 47.335' E from the shoreline). The offshore zone here is a cryptic habitat consisting of a muddy bottom and is dominated by *Caulepa* spp. (Fig. 5). Here, significant 'gardens' of the worm seem to be growing virtually unchecked, and would presumably be exerting some influence on the surrounding biota.

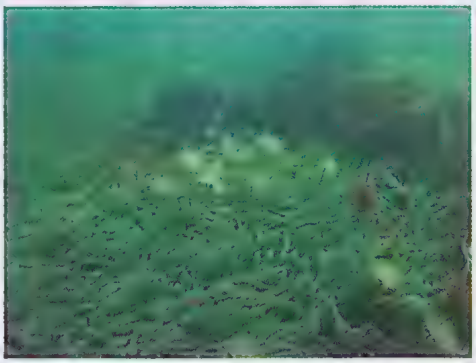

Fig. 5. A 'hotspot' of *Sabella spallanzanii*, photographed in approximately 6 m of water near the offshore boundary line of Point Cooke Marine Sanctuary.

Transect line and quadrat sampling demonstrated that overall infestation levels of *S. spallanzanii*, even in hotspots, were not particularly heavy. Of the 120 m^2 that were surveyed (many of which were in hotspots or areas of relatively high abundance), a total of 411 *S. spallanzanii* were detected, averaging out to 3.43 m^{-2}. Figure 6 demonstrates the number of *S. spallanzanii* detected per transect line. It is worth noting here that transects 11 and 12 were conducted over relatively sandy, barren habitat, while most of the rest were conducted over either a muddy bottom, or areas that were interspersed with some sections of basalt reef, suggesting a probable habitat preference for the muddier sections of the sanctuary and those with a hard substrate for the worms to attach themselves to.

In the more densely populated areas of PCMS, the most common number of *S. spallanzanii* detected per m^2 was four, with a minimum of zero and a maximum of nine individuals (Fig. 7).

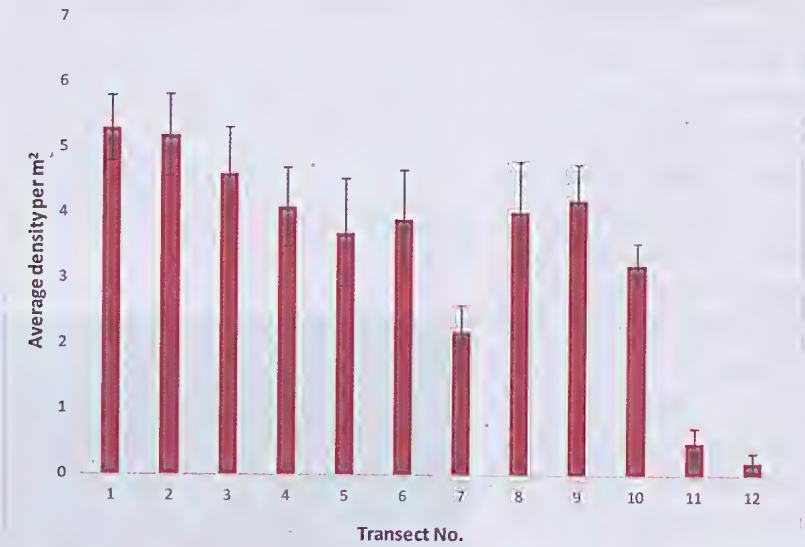

Fig. 6. Average densities of *Sabella spallanzanii* along 10 m long transect lines of 10 m² area, demonstrating the average densities per m².

Fig. 7. Numbers of *Sabella spallanzanii* detected per m² and the frequency of occurrence of observations.

Densities of* Sabella spallanzanii *at Gem Pier, Williamstown

As previously mentioned, densities of *S. spallanzanii* at Gem Pier in Williamstown (37°86.21' S, 144°90.53' E) were found to be relatively very high. This habitat is within a marina, and could be described as being anthropogenic and highly disturbed. It may also have a relatively high nutrient loading, presumably making conditions perfect for high densities of *S. spallanzanii*. *Sabella spallanzanii* had attached themselves to the underside of the wooden pier in huge numbers, as well as inhabiting the muddy bottom (particularly that which was in shadow directly underneath the wooden structure of the pier). The area was also found to be well populated by the invasive Japanese kelp or wakame *Undaria pinnatifida* and the Northern Pacific seastar *Asterias amurensis*.

To get an idea of the numbers of *S. spallanzanii* encountered at Gem Pier, please refer to the video files at https://youtu.be/cJBL0N6YYAM. For comparison, please refer to https://youtu.be/_eREogjbh1w, which provides footage of a hotspot that was filmed at PCMS.

As if to underscore the patchiness of *S. spallanzanii* at Gem Pier, an attempt was made in May 2018 to quantify its actual densities, but, since they were investigated in 2015, these densities had nosedived to the point where relatively few individuals remained. It was noted that the pier now had an extremely heavy covering of mussels, which may have been competitively excluding *S. spallanzanii* and markedly reducing their densities in this particular location. This appears to support the characteristic patchiness and population booms and busts which occur among many marine pest species as well as native species.

Sabella spallanzanii *removal*

Sabella spallanzanii were relatively easy to remove from their muddy benthos habitats. The best way to remove them appeared to be manually. Using gloves for protection, the diver closely grasped the base of the tube and gave a firm but steady pull. The entire organism was often freed from the benthos in one piece without being damaged or fragmented. The animal was invariably still alive (as evidenced by the extension and retraction of its fan apparatus), and could then be analysed, euthanised and disposed of at a later stage, if required. *Sabella spallanzanii* were much more difficult to

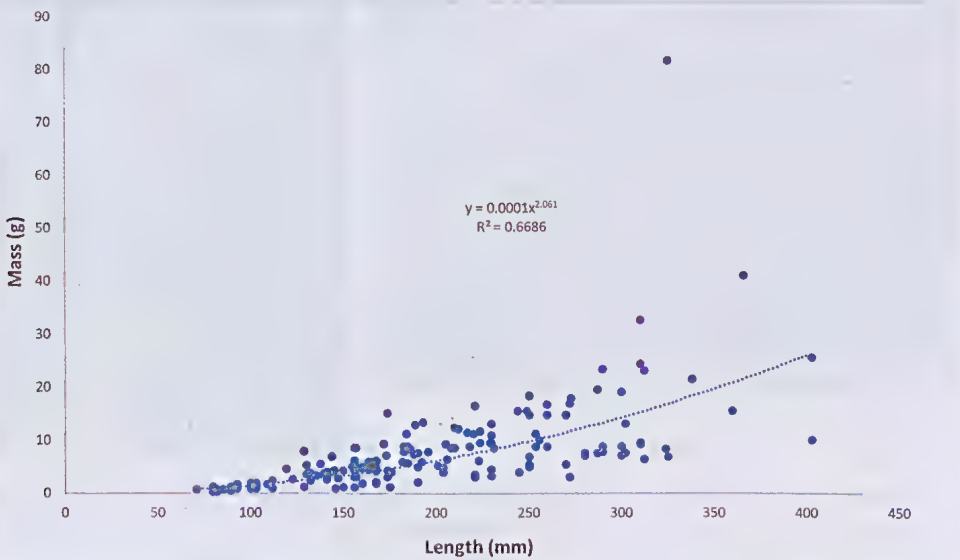

Fig. 8. Length vs mass regression for *Sabella spallanzanii* removed from Point Cooke Marine Sanctuary (n = 161).

remove from hard substrates, such as basalt reef or jetty pylons; attempts to remove them sometimes resulted in considerable damage to the worm, with protective tubes being split, exposing the worm inside.

Morphometric analysis

As predicted, there was a relatively strong relationship between the length and mass of *S. spallanzanii* (Fig. 8) that were measured in their tubes, and a stronger relationship once the tube had been completely excised (Fig. 9).

It is evident that one *S. spallanzanii* (with a length of 325 mm and a mass of 82 g) was a rank outlier due to a considerable degree of biofouling on its tube; this same individual was found to merge well with its conspecifics in an analysis once the tube had been removed, resulting in a new weight of just 7 g (Fig. 9).

When considering the length–frequency distribution of *S. spallanzanii* at Point Cooke Marine Sanctuary, a classic bell-shaped curve emerges, with something of a skew towards the right. The most common observations consisted of worms from 150 to 199 mm in length (Fig. 10).

A sampling bias probably exists here, since individuals less than about 50 mm in tube length could be expected to remain invisible on a substrate that is covered with macroalgae and are not 'tall' enough to be seen above the macroalgal cover. Interestingly, the 50 mm tube length coincides with the size at maturity of *S. spallanzanii* in Australia; the same species does not reach maturity in its native Italy until it reaches 150 mm (NIMPIS 2017).

The prominent fans of this species (sometimes referred to as a branchial crown (Notti *et al.* 2007) or feeding tentacles (NIMPIS 2017)) are certainly a giveaway when viewed from 'ground level;' that is, when a scuba diver or snorkeller is in proximity to the benthos (Fig. 11). It is worth noting here that, when viewed from directly above, *S. spallanzanii* fans have a tendency to blend into the background, due to their relatively light coloration (Fig. 11), and the often murky water that is characteristic of PCMS makes visibility more difficult.

The mass–frequency distribution of *S. spallanzanii* sampled during this investigation differed from the length–frequency distribution

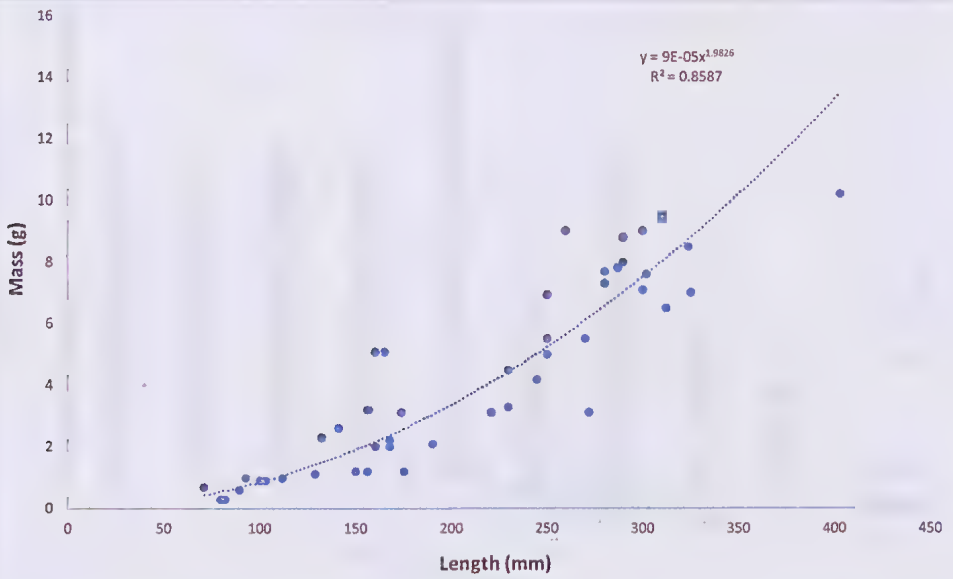

Fig. 9. Length vs mass regression for *Sabella spallanzanii* removed from Point Cooke Marine Sanctuary that had their external casings ('tube') removed (n = 47).

Fig. 10. Length-frequency distribution for *Sabella spallanzanii* removed from Point Cooke Marine Sanctuary (n = 161).

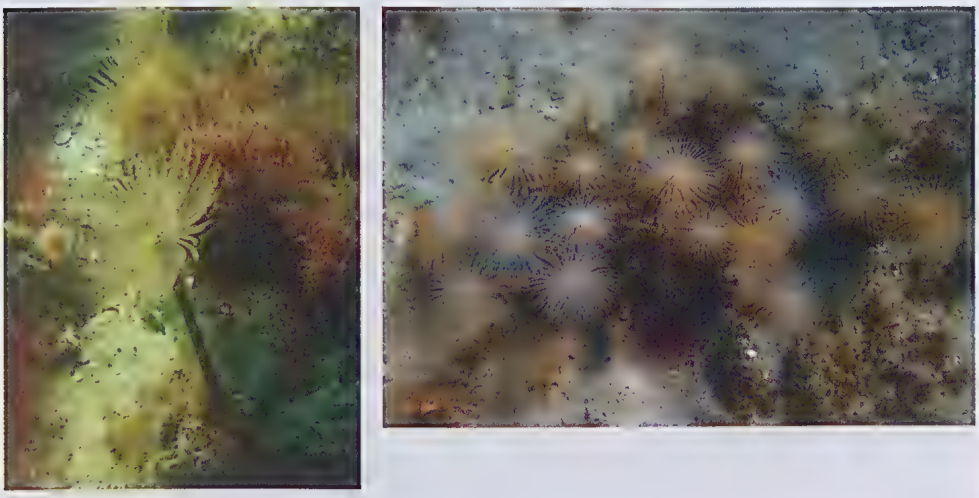

Fig. 11. The prominent fan apparatus and tube of *Sabella spallanzanii* is readily visible when viewed from the substrate (left), while it may blend into the background when viewed from directly above, and the tube is generally hidden from view (right); this image shows at least 21 *S. spallanzanii* in a relatively small area, demonstrating the characteristic patchy abundance of the species.

because it was skewed more strongly towards the right, where masses were relatively minimal. The vast majority (78%) of *S. spallanzanii* analysed were less than 10 g in mass, with only four individuals (or 2.48%) weighing more than 25 g (Fig. 12).

Do not use this invasive species for bait!

While this article is of course intended for the public record, it may be worth keeping this next fact quiet; when *S. spallanzanii* has its protective casing removed (Fig. 13), what results is a naked worm that may be 300 mm in length.

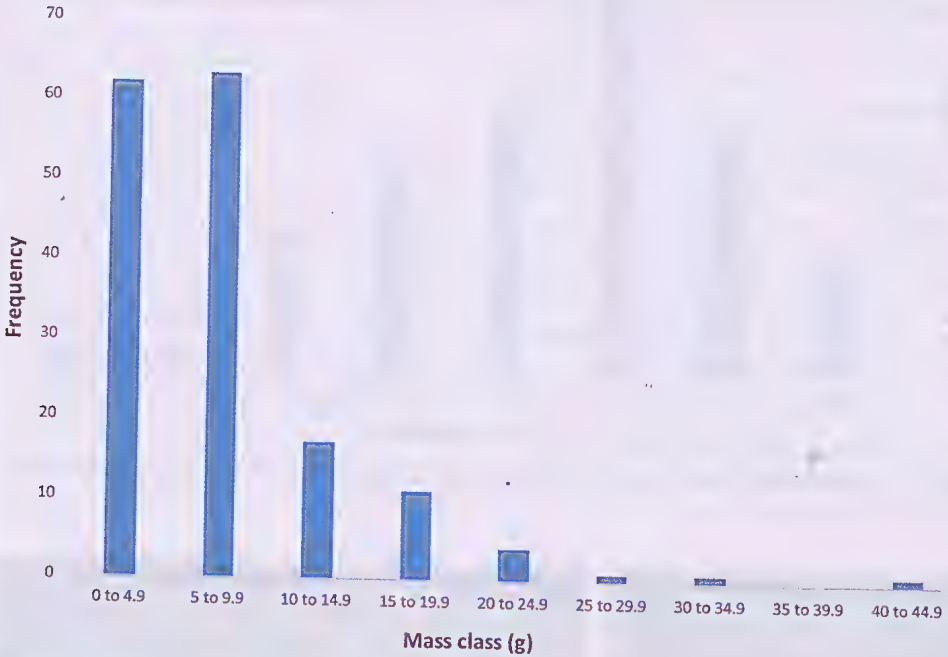

Fig. 12. Mass-frequency distribution for *Sabella spallanzanii* removed from Point Cooke Marine Sanctuary (n = 161).

Fig. 13. An example of a *Sabella spallanzanii* 'tube', the protective casing of mucous that collects sand grains and other detritus and solidifies over time. This one has been removed with dissecting scissors and a scalpel blade in the laboratory, but they are often found washed up on the shore long after the animal has died. In this way they can function as an important indicator of the presence of this marine pest species in any location.

This means that some anglers may view it as an attractive bait source for a variety of recreationally targeted finfish (though it is quite a hideous looking beast in this guise! See Fig. 14). Such a long worm on the end of a hook would no doubt be irresistible for many fish species, but of course this practice must be actively discouraged; *S. spallanzanii* may shed its gametes when its structural integrity is compromised as a result of baiting or fish attack, which could extend its range.

It is unlikely that *S. spallanzanii* could become the next exotic baitworm of choice for anglers because of the relative difficulty in procuring it (removing it from underneath piers requires at least a set of waders or snorkel gear, and is more labour intensive than traditional bait pumping for other polychaete species) and processing it (particularly slicing off the case), but it is certainly something that should be guarded against by authorities. *Sabella spallanzanii* is often used as bait to capture sparid finfish in its native Italy, and it is also fed to leatherjackets in aquaria (NIMPIS 2017).

***The fan apparatus of* S. spallanzanii**

A considerable part of *S. spallanzanii's* impact on the biota involves the elaborate fan system (more correctly referred to as radioles) that the animal extends during normal suspension feeding, and retracts when threatened or when local conditions (such as strong currents) are unfavourable. As expected, our research demonstrated that there was a significant positive correlation between the total length of the animal and the length of its radiole apparatus (Figs. 15 and 16). This, no doubt, has implications for the sheer volume of water that this fan worm can filter in any given hour.

If we consider the length of the fan as a percentage of overall total length (Fig. 16), it becomes clear that the relative size of the fan tends to be larger in smaller individuals; while the radioles no doubt grow, it seems that *S. spallanzanii* 'grows into' its radioles to a certain extent, and starts out with fans that are relatively large when compared to the overall size of the animal. This is one of the most important features (Fig. 17) of this particular sabellid polychaete.

Fig. 14. An example of *Sabella spallanzanii* with its protective casing removed, demonstrating the somewhat ghastly appearance of the worm beneath, but the potentially powerful allure of the animal for use by anglers as bait, which must be resisted.

Biofouling and integration into benthic communities

It is interesting to note that while *S. spallanzanii's* translocation to different areas could be due in part to its tendency to attach to the hulls of vessels (hull fouling), it too falls victim to biofouling (See front cover). The extent of fouling on individual *S. spallanzanii*, particularly in areas of high infestation, or 'forests', has been previously documented (Ross *et al.* 2013). It is invariably the case that marine pests will be integrated somehow into the local ecology

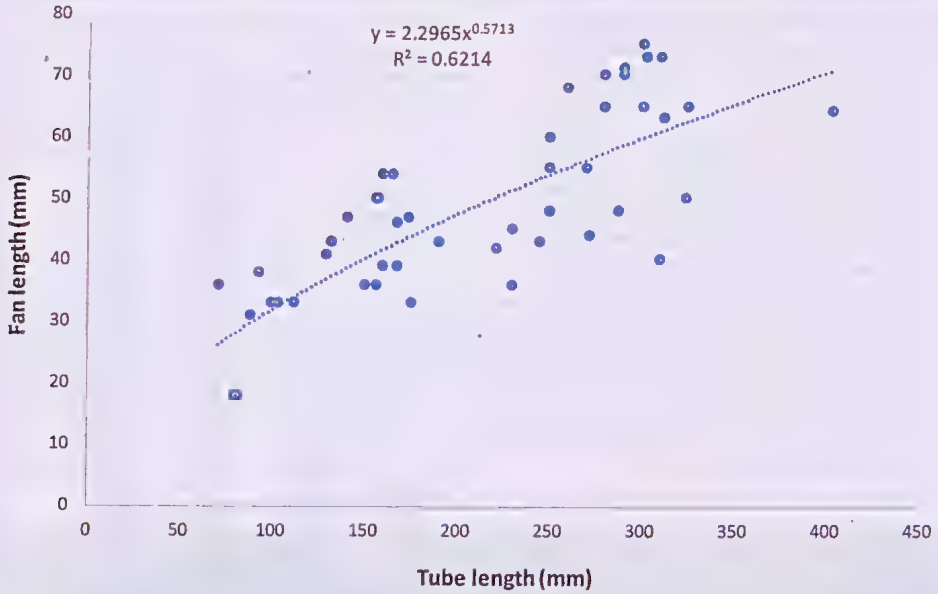

Fig. 15. Total tube length vs fan length for *Sabella spallanzanii* from Point Cooke Marine Sanctuary (n = 47).

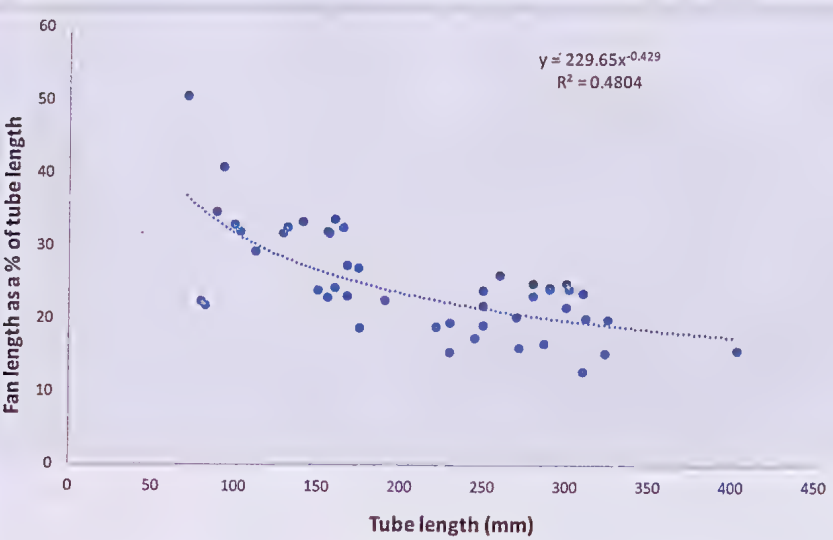

Fig. 16. Tube length vs fan length as a percentage of tube length for *Sabella spallanzanii* from Point Cooke Marine Sanctuary (n = 47).

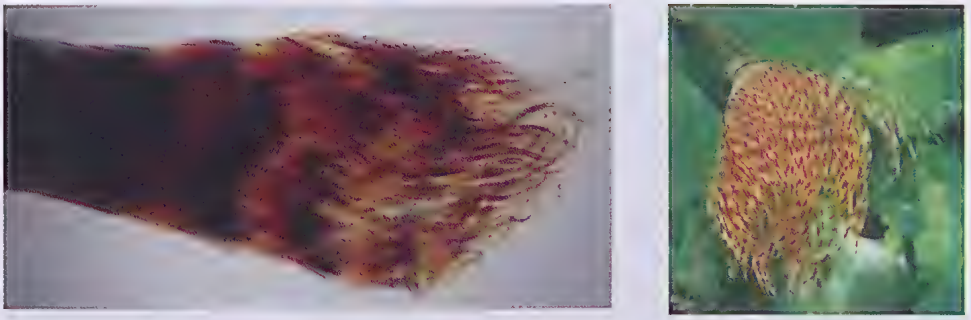

Fig. 17. The 'fan' or radioles of *Sabella spallanzanii* displayed under a dissection microscope, showing the fine structure of the filaments that the animal uses in its habit of filter-feeding (left), and *S. spallanzanii* deploying radioles while attached to a jetty structure (right).

(Rilov 2010). The fact that some of the larger *S. spallanzanii* in PCMS are attracting an enormous number of fouling organisms, and seemingly functioning as reef structures themselves, could be seen as evidence of this.

For the most part, it is clear that *S. spallanzanii* does not currently pose much threat to the biodiversity of Point Cooke Marine Sanctuary. Major tracts of the sanctuary lack any evidence of *S. spallanzanii*, and, overall, densities of this fan worm are too small to warrant major concern at present, though the situation is worthy of monitoring into the future. At PCMS, *S. spallanzanii* appears to be patchily distributed; lone individuals or clumps of three or four individuals are quite common throughout the sanctuary, especially in areas such as subtidal seagrass meadows, muddy benthos and basalt reef at depths of five to seven metres. Some areas are clearly 'hotspots' for *S. spallanzanii*, and in these areas it may be exerting a considerable influence, though the densities observed are relatively minimal compared to the massive densities readily observed on some anthropogenic structures throughout Victoria, such as Gem Pier in Williamstown. Some massive densities of *S. spallanzanii* have been reported in the literature, with estimates of 100 m^{-2} (NIMPIS 2017) and 250 m^{-2} (Aquenal 2008) being indicative of what was discovered at Gem Pier.

The radioles of *S. spallanzanii* are capable of filtering an enormous amount of water every hour, and as suspension feeders their key ecological impact appears to be the provision of competition for other filter and suspension feeders, such as sponges and cunjevoi (sea squirts), which are both very common throughout PCMS. *Sabella spallanzanii* has the potential to reduce the value of natural habitats by forming dense colonies or 'forests', thus reducing enjoyment of marine protected areas, such as that described in this study, for recreational snorkellers and scuba divers.

The rapid rate of anthropogenic change to the Point Cook area and Wyndham Shire could increase the prevalence of *S. spallanzanii* throughout the region, but this still remains to be proven.

At present, perhaps the greatest agent of change in PCMS is the purple sea urchin *Heliocidaris erythrogramma*, which appears to be functioning as a true 'ecosystem engineer', and which may be symptomatic of a system out of balance. The numbers of these animals have exploded to the point where they have formed, and continue to form, large 'urchin barrens', areas that have largely been stripped clear of macroalgae in the marine sanctuary. The urchins appear to be modifying this habitat so much that they have even been observed interacting with the subject of this article (Fig. 18)!

Removal of Sabella spallanzanii by friends groups, and management options for the future

The fact that it is unlikely to be confused with any native species (such as *Sabellastarte australis*, which has not been seen by the authors within Point Cooke Marine Sanctuary or Gem Pier at Williamstown) or *Myxicola infundibulum* (most of which is hidden entirely below the sediment with the exception of its branchial crown

Fig. 18. A live example of *Sabella spallanzanii* being interfered with (and flattened!) by a purple sea urchin *Heliocidaris erythrogramma*. This photograph demonstrates the difference in abundance of fan worms versus sea urchins in this particular location.

or 'fan') means that *S. spallanzanii* is potentially a very good candidate for removal by volunteers with relatively limited training. At last count, three marine-based friends groups (Marine Care Point Cooke, Jawbone Marine Sanctuary Care Group and Marine Care Ricketts Point) were located in northern Port Phillip Bay; many of their volunteers are ideally suited to removing marine pests such as *S. spallanzanii*.

As the highest densities of *S. spallanzanii* have been encountered in the relatively deep waters of PCMS (from 4 m to 7 m deep at high tide, which equates to distances of roughly 600 m to 800 m offshore), significant removal can be carried out only with the assistance of scuba apparatus. Snorkelling would be an option only for those of excellent physical fitness and capabilities; shallow water blackout is a risk in situations where snorkellers need to make repetitive deep dives. Realistically, eradication should not be an aim of a marine friends group in a 290 ha marine sanctuary (due to the sheer amount of continuous effort involved), but the thinning out of populations of these animals could certainly be an achievable aim for such groups.

Direct control of *S. spallanzanii* is most likely to be limited to physical removal, including hand-picking by snorkelers and divers. In areas with relatively sparse populations, such as at PCMS, a regular removal program could make a significant difference to the abundance of *S. spallanzanii* and potentially halt any future advance. That said, it would be beneficial to establish whether or not *S. spallanzanii* sheds gametes when disturbed, i.e. after being plucked from a soft muddy bottom. If *S. spallanzanii* does indulge in this behaviour, the types of catch bags used would need to be considered carefully, as would methods (such as the use of kayaks) for removing it quickly from the water.

Conclusion

Overall, *S. spallanzanii* does not appear to be exerting a very significant impact on Point Cooke Marine Sanctuary on account of its relatively minimal densities. There are certainly 'hotspots' within the sanctuary, but these densities pale in significance when compared to the levels observed by the authors at Gem Pier in Williamstown. Despite initial fears of a mass in-

vasion by this marine pest species, it seems that *S. spallanzanii* does not currently pose a great threat to PCMS. That said, *S. spallanzanii* does present itself as an ideal candidate for further study and the development of 'citizen science' projects.

Acknowledgements
The authors would like to extend their heartfelt thanks to the Environment Fund of the Field Naturalists Club of Victoria, which funded the research project. The work was ably supported by Parks Victoria, in particular Bernie McCarrick, Russell Brooks, Mark Cullen, Dr Sue Hadden and Morgan Pumpa. The project was carried out with the assistance of volunteers from Marine Care Point Cooke, a friends group devoted to the conservation, study and enjoyment of Point Cooke Marine Sanctuary. We also wish to extend our thanks to the staff and students of Melbourne Polytechnic's Bachelor of Agriculture and Technology degree program, most notably Scott Brander in the Aquaculture Program for his technical assistance in preparing quadrats, and to Paul Liew for his able assistance with field-based sampling. Thanks are also extended to Tia Vella of the John Monash Science School for her assistance with the analysis of samples in the laboratory.

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One Hundred and Three Years Ago

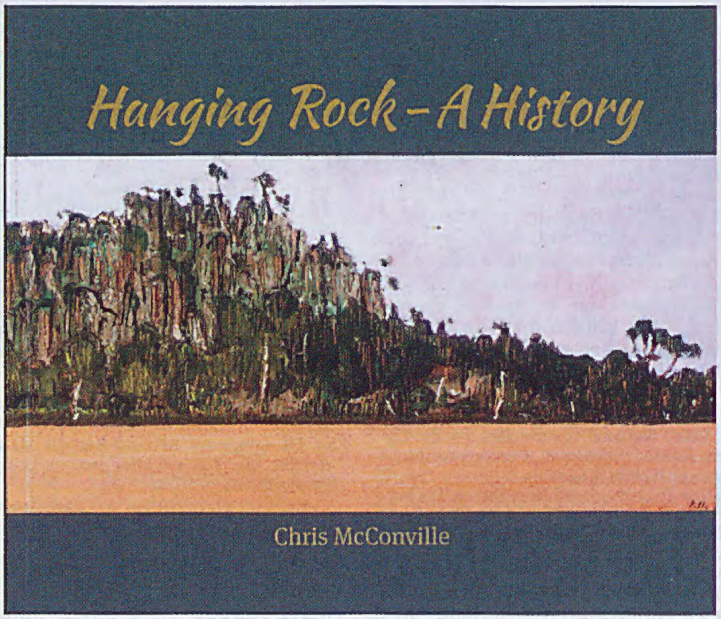
Mr. J. Searle, in referring to his exhibit of specimens of sea-pens, collected at Western Port, gave some account of the life-history and method of growth of this group of animal life. He said that the family Pennatulidae contains some of the most beautiful of fixed marine animals. The sea-pens are colonies of little polyps, differing from the coral polyps, to which they are related, in that, instead of secreting calcareous tubes in which to dwell, they are supported by a limy central rod, which is covered with a fleshy coenosarc; this branches out in a number of pinnae, along which the polyps grow. They are brilliantly coloured, and some are very luminescent. They live fixed on the bed of the sea, the stalk-shaped portion lifting the polyp-bearing part above the sea bottom. The primary polyp is developed from a fertilized egg, and forms the main axis on which the secondary polyps are carried; these, in turn, by means of stolans, give rise to tertiary polyps, and so the colony grows.

From *The Victorian Naturalist* **XXXII**, p. 67, September 1915

Hanging Rock — a history

by Chris McConville

Publisher: *Friends of Hanging Rock Inc., Woodend, Victoria, 2017. 264 pages, softback. ISBN 9780648166603. RRP $29.99*



There must be few natural features in Victoria that have the iconic status in the public imagination that attaches to Hanging Rock. Since Joan Lindsay's 1967 novel and, more particularly, Peter Weir's film adaption, Hanging Rock has exercised an attraction over an increasingly wider audience. Chris McConville's *Hanging rock — a history* sets out to show that, in fact, the mysterious and otherworldly nature of the Rock, and its power to stir human imagination, has always been a part of its being. This book grew out of a popular movement to oppose the building of a major wellness centre in the Eastern Paddock, adjacent to the monolith, in 2013. Details of both the proposal and the opposing force are spelled out in the final essay, but are hinted at near the end of the book's introductory chapter.

This history of Hanging Rock is told through a series of nine thematic essays, each of which deals with a different facet of the Rock's past. A major theme that runs through these essays is of Hanging Rock as a locale of enduring mystery, a place that excites imagination. Since the beginnings of European exploration and settlement in the area, Hanging Rock and its immediate surrounds have been the setting for a variety of social and cultural events. These have ranged from race meetings (since the 1860s), rock music concerts (from the late 1980s) and, of course, annual picnics on New Year's Day. In the detailing of all of these events, the Rock is presented as looming large as a backdrop, and perhaps a silent participant.

Following an introductory piece, suggestively titled 'Spectre in the mist', the order of these chapters is essentially chronological, although there is much movement back and forth be-

tween some of the subject areas within the overall narrative. The initial essay, 'First people' focuses, *de rigueur*, on the role of Hanging Rock in the lives and culture of the local Indigenous groups. Here, McConville uses what little is known in relation to these matters and is at pains to show that the Rock was of great importance to the Aboriginal people of the area. He makes much of the relative proximity of the well-known Mount William greenstone quarry, although there doesn't appear to be any obvious material or cultural connection between the two sites.

The following chapter, 'Volcanic wilderness', looks at the natural history of the Rock and its surrounding area. There is some discussion regarding the vegetation and animal life, as noted by the earliest explorers and the naturalists who followed later. Perhaps fittingly, much of this essay is devoted to a discussion of the geological genesis of Hanging Rock, and related theories developed by visiting geologists in the latter half of the 19th century.

The succeeding six chapters each focus on a specific way in which the surrounding area of Hanging Rock, particularly the Reserve, has been used over the past 170-odd years. 'Around the Rock' details the spread of settlement, from the pastoralists of the 1830s, followed by more permanent farmers, through to the creation of small towns and hamlets. 'Little Flemington' is the story of Hanging Rock Racing Club, and the creation of a racecourse, with regular New Year's Day meetings. 'Carnival times' looks at the use of the Hanging Rock Reserve as a place of public relaxation and entertainment, and the management issues that ensued as visitor numbers grew. 'Vanishing heights', followed by 'Cinema place', examine Joan Lindsay's famous novel and Peter Weir's film adaptation respectively, putting each within its social context, as well as looking at the impacts each has had on public imagining of the Rock. The most recent (and still continuing) use of the Hanging Rock Reserve is detailed in 'Rock icons'. This is the staging of concerts and music festivals that have seen internationally known performers including Bruce Springsteen, Rod Stewart, and Leonard Cohen, as well as topline Australian bands, entertain audiences of tens of thousands of fans. Beginning in the early 1990s, these concerts aimed at raising funds for the Hanging Rock management committee, money that was badly needed to pay for the maintenance and later redevelopment of the Reserve.

The final chapter of this history, 'Red tape and renewal', is an interesting, if somewhat inconclusive, discussion of the difficulties that exist in creating an acceptable and feasible management plan for a place like Hanging Rock. In the case of Hanging Rock, the range of stakeholders and vested interests is so varied and wide as to be largely irreconcilable; and as McConville points out: 'selecting and dividing up stakeholder interests can exaggerate differences and presage indecision' (p. 235).

This book is beautifully presented and profusely illustrated, with more than 140 illustrations, comprising about 60 per cent of the volume. Many of these images cover a full page, and in a few cases spread over two adjacent pages. But where this happens, the central part of the illustration cannot be seen, because of the book's tight binding.

More rigorous editing might have saved the author putting into print some rather basic errors, such as asserting that magma and lava are different types of rock (p. 8), or referring to Robert Hoddle in the 1840s as 'the surveyor of the new British colony of Victoria' (p. 29); as well as simple typos such as 'Barker' for Parker (footnote 1, p. 48), or 'Presland, P.' in the bibliography (p. 238).

It can't have been easy writing a history of an entity that literally does nothing. The 'history' of Hanging Rock surely coheres in the plethora of human actions that have occurred on or around the Rock, rather than anything done by the Rock itself. That said, it might be claimed reasonably that Hanging Rock has an attractive quality, one which draws people to its presence. McConville has done a good job of trying to adduce what that quality is, and the extent to which it has been a factor in the cultural history of Hanging Rock.

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